N91-21370

Feedback Controlled Electrostatic and Electromagnetic Sample Positioners

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Four different sample positioners will be discussed in this presentation. Three of them are electrostatic systems each of which operates at the different operational condition. The fourth positioner is the electromagnetic system which positions conducting samples. However, these four systems share a common operating principle in that the sample positioning is achieved by feedback controlled forces which can be electrostatic, dielectrophoretic, or electromagnetic. The first system is the electrostatic liquid drop positioner which operates at the near ambient condition. Containerless protein crystal growth and cell culturing experiments require the liquid drop positioner with temperature/humidity control and appropriate diagnostic capabilities, while the experiments on charged drop dynamics may require the electrostatic-acoustic hybrid system in which drop oscillation or rotation can be induced acoustically. The multi-drop positioning system developed for the protein crystal growth and biological applications will be described in a separate presentation, and a detailed description will be focused on the electrostatic-acoustic hybrid system for its capabilities and limitations for the drop dynamics experiments.

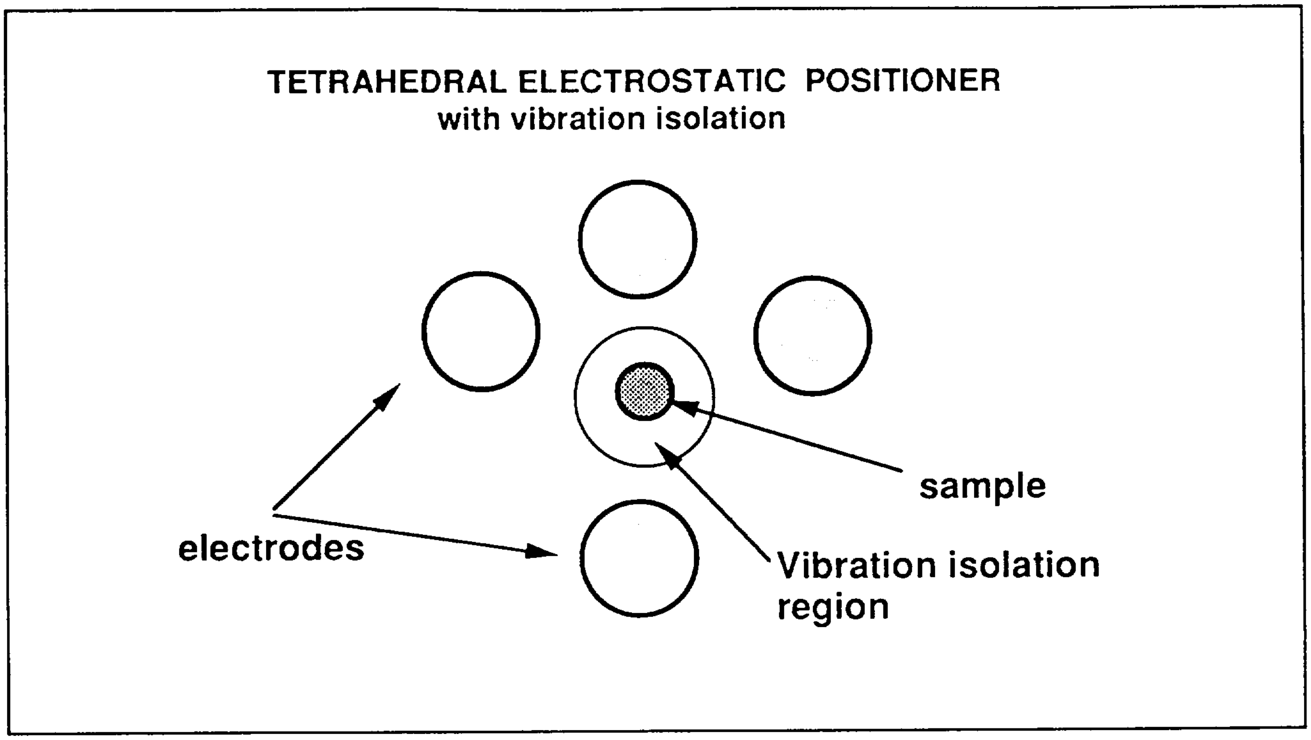
The second system is the tetrahedral electrostatic positioner which is being developed fo, the high temperature materials processing in vacuum. Tetrahedral system is capable of three dimensional position control and damping. Being a microprocessor controlled positioner, various modes operation can be generated all through software programming. In the tight control mode, the positioner keeps the sample at a fixed position and damps any transient movement about this position. In the soft control mode, the system allows the sample to freely float within a preassigned region so that the sample can be isolated from most of the oscillatory disturbances generated by the spacecraft. The presentation will include sample charge behavior as different materials were heated up to 1250°C, sample charging by electron guns, and a method of inducing sample rotation. This section will be concluded with the prospect of this system as a flight module.

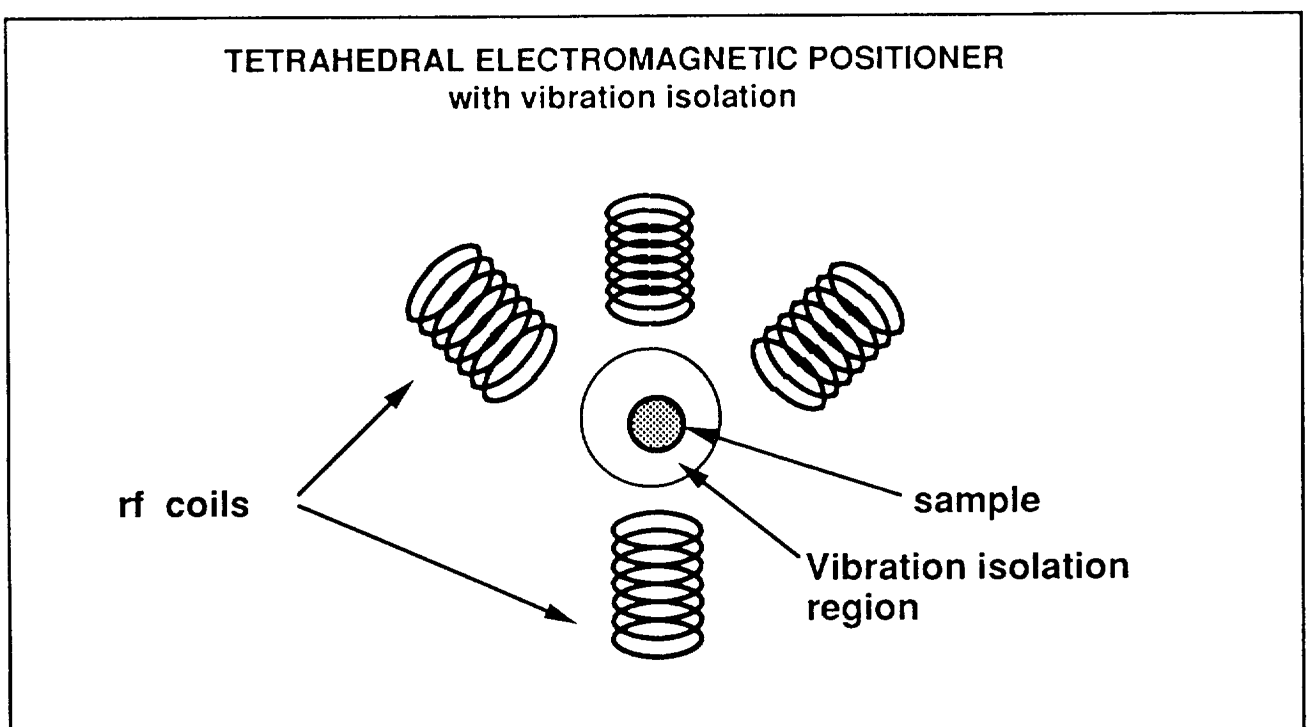
The third system is essentially the same tetrahedral system described above except that, in this mode of operation, the position control is achieved by dielectrophoretic forces in the pressurized gas environment. This system is being developed for those materials which contain volatile components.

Finally, the feasibility of a feedback controlled electromagnetic positioner will be presented. This approach is based on the same principle as the tetrahedral dielectrophoretic positioner as far as the basic principle of operation is concerned. Four coils are arranged in a tetrahedral configuration and positioning forces are generated by the same positioning algorithm used in the tetrahedral electrostatic systems. This system will have the same capabilities of positioning, damping, and vibration isolation as electrostatic systems. As long as the sample has appreciable electric conductivity, this system will be operable both in gaseous and vacuum environments. An additional advantage of this system will be that the sample rotation can be induced or damped in a controlled way which is not possible in the conventional electromagnetic positioners known today.

Tetrahedral Electrostatic/Electromagnetic Sample Positioners

- Electrostatic positioning
  - charged samples
  - feedback controlled DC electric field
  - conducting or nonconducting materials
  - solid or liquid phase
  - vacuum or controlled gaseous environment
- Dielectrophoretic Positioning
  - no sample charges
  - feedback controlled DC (or AC) inhomogeneous electric field
  - conducting or nonconducting materials
  - solid or liquid phase
  - vacuum or controlled gaseous environment
- Electromagnetic Positioning
  - feedback controlled rf magnetic field
  - conducting sample materials
  - vacuum or controlled gaseous environment


TETRAHEDRAL ELECTROSTATIC POSITIONER
with vibration isolation
electrodes
sample
Vibration isolation
region


TETRAHEDRAL ELECTROMAGNETIC POSITIONER
with vibration isolation
rf coils
sample
Vibration isolation
region

Tetrahedral Eletrode/Coil Arrangement

- Open structure
- Clear sample viewing
- Easy access to diagnostic instruments
- Decoupled positioning and heating
- Enough space for vibration isolation

Feedback Controlled sample positioning

- Minimum control force in response to external perturbation
  - Positioning: with stability better than 20 microns
  - Damping: controlled damping factor
  - No internal/external flow
  - No rotational instability
- Perturbation free region: programmable
  - absolute quiescence in the region (~10 sec)
- Selection of sample position: +/- 5 mm
- Controlled sample velocity: TBD

Electrostatic-Acoustic Hybrids

- Utilization of feedback controlled electrostatic sample positioning capabilities
- Utilization of acoustic sample manipulation capabilities (oscillation and rotation)
- Charged drop dynamics, crystal growth, cell culturing